Thermal review of CLIC module

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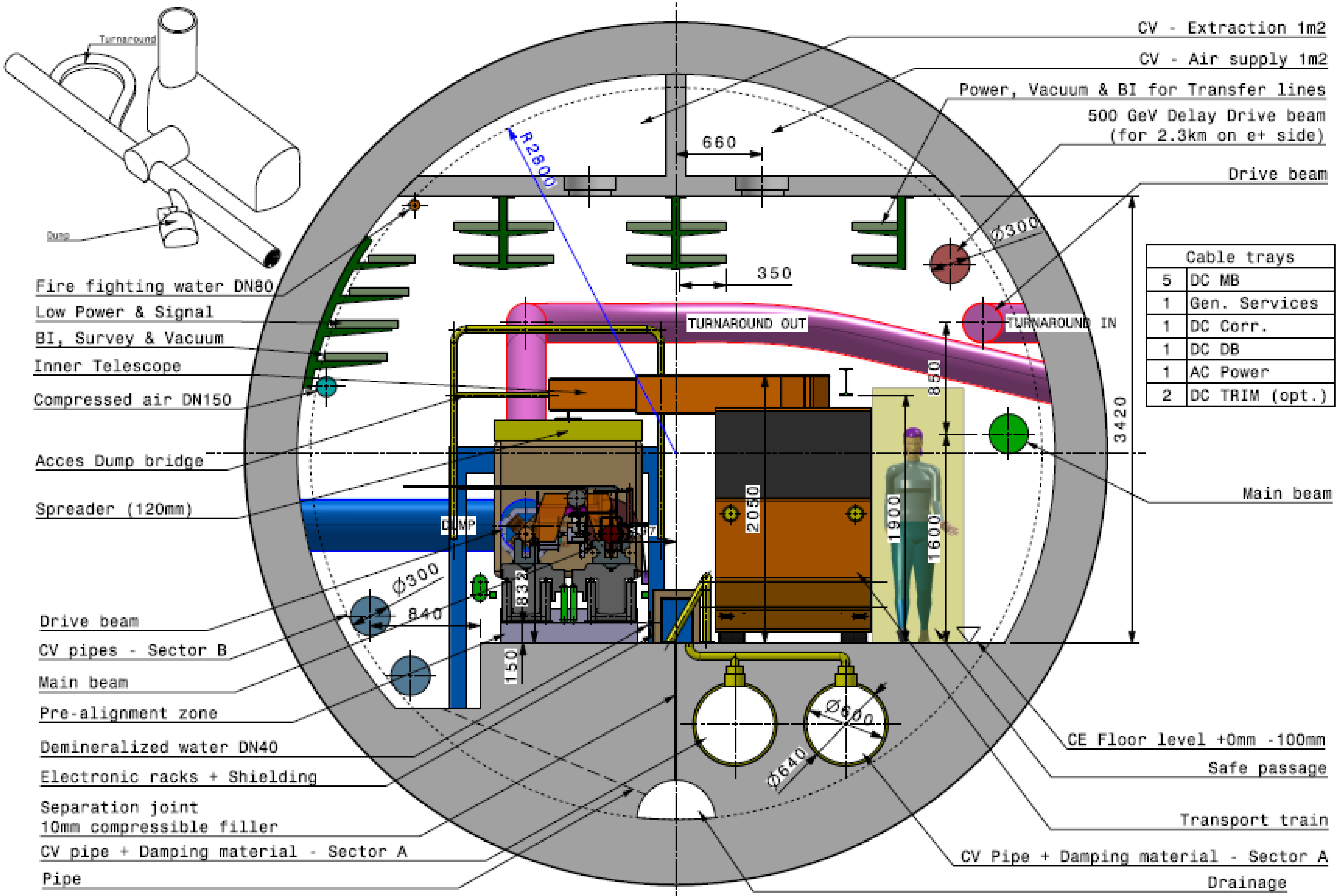
03.03.2017

Module power

- Very nice work prior to CDR: Two-beam module: estimated power dissipation (EDMS# 910399) (last update from 23.11.2010)
- All calculations are taking total power of linac divided by length
- Update to todays technology and knowledge



CLIC - Typical Cross Section - Diameter 5600mm - Junction with Turnaround - 1:25
Draft - J.Osborne / A.Kosmicki - August 9th 2010

Heat sources in Tunnel:

1. Module
2. Transfer lines
   a) Magnets
   b) Vacuum pumps
   c) Instrumentation
   d) Cables (including kickers)
3. Cables for turnarounds?
4. Cables for DB dumps?
5. …

Alignment system	**H. Mainaud-Durand**	(values updated on 03.06.2010)			
Movers girders			Movers MBQ		
108	W/girder [12 W/st. Motor]		60	W/MBQ [12 W/st. motor]	
5%	duty cycle %		5%	duty cycle % [before operation]	
12366	No girder MB		1996	No Q	
10370	No. girder DB				
122774.4	W [Tot per linac]		5988	W [Tot per linac before operation]	
5115.6	W [Tot per DB sector]		249.5	W [Tot per DB sector]	
Total Girders + MBQ		128.7624	kW [Tot per linac]		to air
		5.4	kW [Tot per DB sector]		

Beam Instrumentation system	L. Soby	(values updated on 03.06.2010)			
BPM	Clarification / unit				
13	W/BPM				
1996	No BPM MB				
15555	No. BPM DB				
228163	W [Tot per linac]				
9507	W [Tot per DB sector]				
Total BPM		228	kW [Tot per linac]		to air
		10	kW [Tot per DB sector]		

Vacuum system	C. Garion	(values updated on 29.07.2009)			
For the main linac (1 vacuum sector: ~200m, 4 sectors per DB sector):					
- 1 ionic pump/module/beam; 1 alimentation of 150W for 5 pumps ==> 3kW/sector/beam					
- 1 penning gauge/module/beam; 1 alimentation of 50W for 4 gauges ==> 1.25 kW/sector/beam					
- 8 mobile TM station/sector ==> 8 kW/sector (during conditiong only)					
- NEG cartridge: 200 W/module ==> 20 kW/sector (during conditioning only)					
Totals Main linac	conditioning		operation		
	N/A	kW [Tot per linac]	408	kW [Tot per linac]	to air
	112	kW [Tot per DB sector]	17	kW [Tot per DB sector]	

Magnet system and magnet powering system	M. Modena D. Siemaszko	(values updated on 07.07.2010)			
MB	total power - coils [W]	total power - cables [W]		number per linac	
MB Type 1	890			154	
MB Type 2	1780			634	
MB Type 3	2600			477	
MB Type 4	3831			731	
	5306.2		kW [Tot per linac]		to water
		132.0	kW [Tot per linac]		to air
DB	total power [W]	total power - cables [W]		number per linac	
MAX	874			20740	
MIN	6.8			20740	
AVE	171			20740	
AVE	3546.54		kW [Tot per linac]		to water
		408.00	kW [Tot per linac]		to air

Stabilisation system MBQs	K. Artoos	(values updated on 14.06.2010)			
	Number/linac	Controller (W)	seismometer (W)	piezo (W)	Total (kW)
Type 1	154	12320	480.5	616.0	13.4
Type 2	634	50720	2967.1	3804.0	57.5
Type 3	477	38160	3720.6	2862.0	44.7
Type 4	731	58480	5701.8	4386.0	68.6
	kW [Tot per linac]	159.68	12.9	11.7	184.2
					to air

RF system	G. Riddone	(values updated on 28.10.2010)			
Input	Total [W]				
AS	410.6	per 1 structure			to water
PETS	88	per 1 structure			
Loads	357.6	per 1 structure			
Waveguides	11.3	per 1 structure			
			WFM		
			13	W/WFM	
			9639	No WFM	
			125.31	kW [Tot per linac]	
			5	W [Tot per DB sector]	
	58401	kW [Tot per linac]			to water
	125.3	kW [Tot per linac]			to air

AS: EDMS# 964717

PETS: EDMS# 964715

Water cooling	67254 kW	3203 W/m
Air cooling	1609 kW	**77 W/m**
Total per linac	68862 kW	

Summary for unloaded case

For C&V input was 110 W/m

	to WATER								
Totals [kW] / linac	AS	PETS	Loads	WG	MB Q1	MB Q2	MB Q3	MB Q4	DB Q
during operation	29319 kW	3142 kW	25535 kW	405 kW	137 kW	1129 kW	1240 kW	2800 kW	3547 kW
	1396 W/m	**150 W/m**	**1216 W/m**	**19 W/m**	**7 W/m**	**54 W/m**	**59 W/m**	**133 W/m**	**169 W/m**
	to AIR								
Totals [kW] / linac	Girder Align	MB Q Align	WFM	Vacuum	BI	DB Q cables	MB Q cables	Stabilisation	RF. Str.
	123 kW	0 kW	125 kW	408 kW	228 kW	408 kW	132 kW	184 kW	
	6 W/m	**0 W/m**	**6 W/m**	**19 W/m**	**11 W/m**	**19 W/m**	**6 W/m**	**9 W/m**	

Certainly very conservative (duty cycle 5%)

Needs review to new PACMAN system

New mini pumps (Nextorr)

Ambient T	Sum RF	% to air	W/m	Total W/m
20	58401 kW	10%	278	**355**
30	58401 kW	3%	83	**160**
40	58401 kW	-4%	-111	**-34**

Klystron machine

Water cooling	60160 kW	2865 W/m
Air cooling	990 kW	47 W/m
Total per linac	61150 kW	

	to WATER								
Totals [kW] / linac	AS	PETS	Loads	Klystrons& WG	MB Q1	MB Q2	MB Q3	MB Q4	DB Q
during operation	29319 kW	0 kW	25535 kW	0 kW	137 kW	1129 kW	1240 kW	2800 kW	0 kW
	1396 W/m	0 W/m	1216 W/m	0 W/m	7 W/m	54 W/m	59 W/m	133 W/m	0 W/m
	to AIR								
Totals [kW] / linac	Girder Align	MB Q Align	WFM	Vacuum	BI	DB Q cables	MB Q cables	Stabilisation	RF. Str.
	60 kW	0 kW	125 kW	408 kW	80 kW	0 kW	132 kW	184 kW	
	3 W/m	0 W/m	6 W/m	19 W/m	4 W/m	0 W/m	6 W/m	9 W/m	

Ambient T	Sum RF	% to air	W/m	Total W/m
20	54854 kW	10%	261	**338**
30	54854 kW	3%	78	**155**
40	54854 kW	-4%	-104	**-27**

Conclusion

- Power to air dissipation is clearly dominated by RF components
- Ambient temperature plays major role

- For new module design two extreme options:

  1. Make a T-resilient design potentially involving expensive material

  $\Rightarrow$ C&V much easier

  2. Make a cheap design

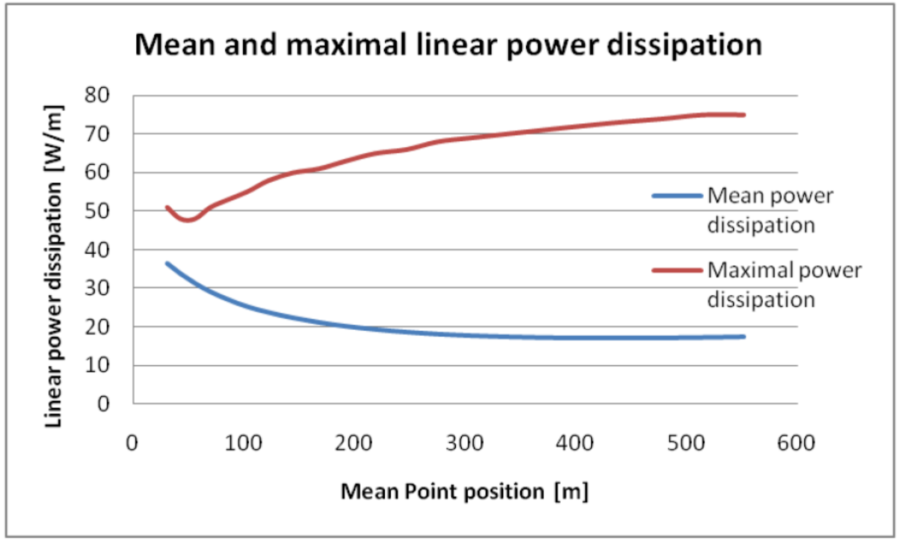
  $\Rightarrow$ C&V much more expensive

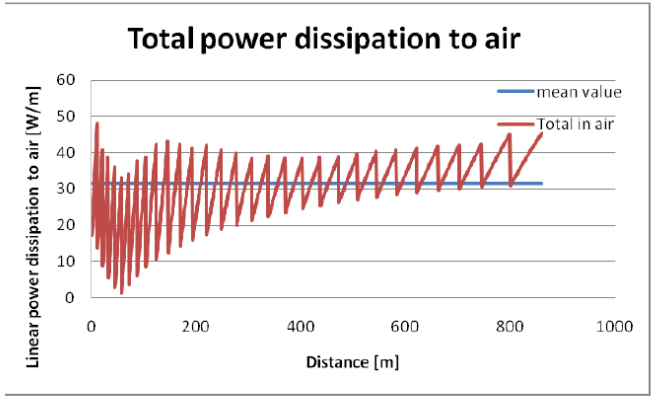
  In reality a compromise have to be found

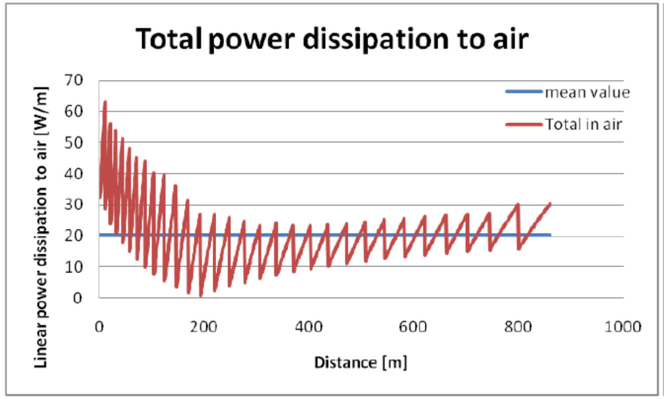
Extra slides

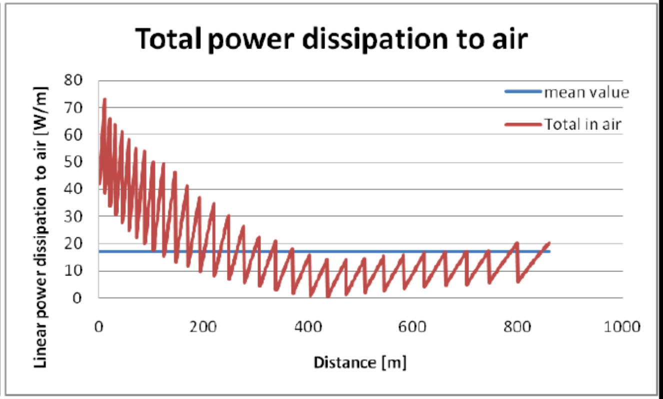
Power dissipation in the tunnel

- The dissipation to air is the sum of the cable dissipation and the trimmers
- The choice of the midpoint (in terms of cabling from the caverns) has an impact on the mean power dissipation and its maximal value.
- Maximal power dissipation can be reduced with the use of thicker cables at higher fields.









Long transfer lines

- MB
  - distance between FODO magnets: 219m
  - BI: BPMs, Beam-loss monitors, etc
- DB
  - distance between FODO magnets: 55m
  - BI: BPMs, Beam-loss monitors, etc

MBQ stabilization extra slide

<u>Controller</u>

About **<u>80 W</u>** . This is however based on the current PXI solution, i.e. it's the power to run the CPU of our controller. This can be reduced by custom designed electronics and we are looking into feasibility of joining controller and/or moving them out of the tunnel.

Type 1: 1
Type 2: 1
Type 3: 1
Type 4: 1

<u>Broadband seismometer and linear power supply (12V, 30 % efficiency)</u>

geohone 0.5 W
Power supply 1.16W **<u>total: 1.56 W</u>**

Type 1: 2
Type 2: 3
Type 3: 5
Type 4: 5

<u>Power for piezo stabilisation or positioning :</u>

Leak current is smaller than micro amps and hence negligible.

The average power needed for steps of 50 nm at a frequency of 50 Hz is smaller than 300 mW. This power is dissipated only once in the sink of the piezo amplifier. With an amplifier efficiency of 30 % i.e. **<u>1 W per actuator</u>**. The heat generated in the piezo is only a fraction of this (for this frequency and step size) and negligible.

The average power for stabilising a low noise back ground is smaller than the power consumed for positioning.

Type 1: 4
Type 2: 6
Type 3: 6
Type 4: 6